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Assessment of Volcanic Risk on the Island of Oahu, Hawaii

By

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards or nomenclature

CONTENTS

ILLUSTRATIONS

TABLES

ASSESSMENT OF VOLCANIC RISK ON THE ISLAND OF OAHU, HAWAII

By DWIGHT R. CRANDELL

INTRODUCTION

A review of the eruptive history of the island of Oahu, Hawaii, suggests that the risk of eruptions within the next few hundred years, or few thousand years, is so low that potential volcanic hazards should not be of substantial concern in planning general land use on the island. There is no certainty that an eruption will ever occur again on Oahu, and even if one should, it probably would seriously affect only a small part of the island.

Nevertheless, the possible effects of eruptions should be considered in planning the location of certain kinds of potentially high risk installations. For example, the safety of a nuclear power reactor throughout its operating life is of paramount concern because of the possible far-reaching consequences of a release of radiation if the reactor were to be damaged or destroyed by a catastrophic geologic event. Such installations should be located in areas of the lowest possible risk.

In this report, a brief summary of the eruptive history of Oahu is followed by a description of the kinds of eruptive phenomena which have occurred in the past. The report concludes with an appraisal of the kinds and probable distribution of volcanic hazards which could result if an eruption were to occur.

The most important points made in the report are as follows:

1. All volcanic activity on Oahu during the last million years has been restricted to the part of the island that lies southeast of a line drawn from Pearl Harbor to the Mokapu Peninsula. If volcanism recurs, it probably will be restricted to the same area.

2. The last eruption on Oahu evidently was between 10,000 and 40,000 years ago, and the last eruptive period was preceded by a dormant interval which may have lasted as long as 200,000 years.

3. Relatively small volumes of rock have been erupted during the last million years, and relatively small areas of land have been affected by any one eruption.

4. The principal products of eruptions during the last million years have been lava flows, cinders and ash, and mudflows. Zones of possible danger from each of these can be anticipated in the event of future eruptions of the same kind in southeastern Oahu.

ERUPTIVE HISTORY OF OAHU

Eruptive activity at the site of what is now the island of Oahu has occurred during three main periods. During the first period, eruptions of basaltic lava built a broad shield volcano in the area now occupied by the Waianae Range (fig. 1). This volcano may have resembled Kohala volcano on the island of Hawaii in its general form and size. Potassium-argon age determinations on lava flows of the Waianae volcano range from about 2.74 to 3.5 million years before present (MacDougall, 1964, p. 114). The Koolau shield volcano, which forms the eastern part of Oahu, was built during the second main eruptive period. Rocks of that volcano range in age from about 2 to 2.5 million years (MacDougall, 1964, p. 115). During the Koolau eruptions, streams began to dissect the Waianae volcano.

The chemical composition of lavas erupted during the life of each shield volcano varied in a definite sequence. The principal bulk of the volcano was formed by copious outpourings of a type of basalt called tholeiite. This phase was followed within a few hundred thousand years by smaller volumes of alkali basalt and chemically similar rocks which are poorer in silicon but richer in potassium and sodium than tholeiite.[1] Near the end of the alkali basalt eruptions, the lavas became richer in silicon and the eruption rate decreased (Dalrymple and others, 1973, p. 26; Macdonald and Abbott, 1970, p. 137-146).

No evidence has yet been found of volcanism on Oahu between about 1 and 2 million years ago, and during that period of inactivity the Waianae and Koolau volcanoes were deeply eroded to form the present mountain ranges of western and eastern Oahu. One possible exception to this generalization exists at Kolekole Pass in the Waianae Range, where a small lava flow of alkali basalt was erupted after the volcano had been deeply eroded. The flow is so deeply weathered that radiometric dating of it evidently is not possible (G. A. Macdonald, oral commun., 1975). The Waianae and Koolau volcanoes probably have both been dormant for at least 2 million years.

The third, or Honolulu, eruptive period began not long after 1 million years ago, and intermittent volcanism continued until sometime between 40,000 and 10,000 years ago (Gramlich and others, 1971). In contrast to the eruptions that built the massive shield volcanoes, the Honolulu period was characterized by relatively small volume eruptions at scattered vents, separated by long time intervals. All of the vents active during that period are in the southeastern part of the Koolau Range, and lie southeast

[1]Only one lava flow of alkalic basalt has been found so far on the Koolau volcano (G. A. Macdonald, written commun., 1975).

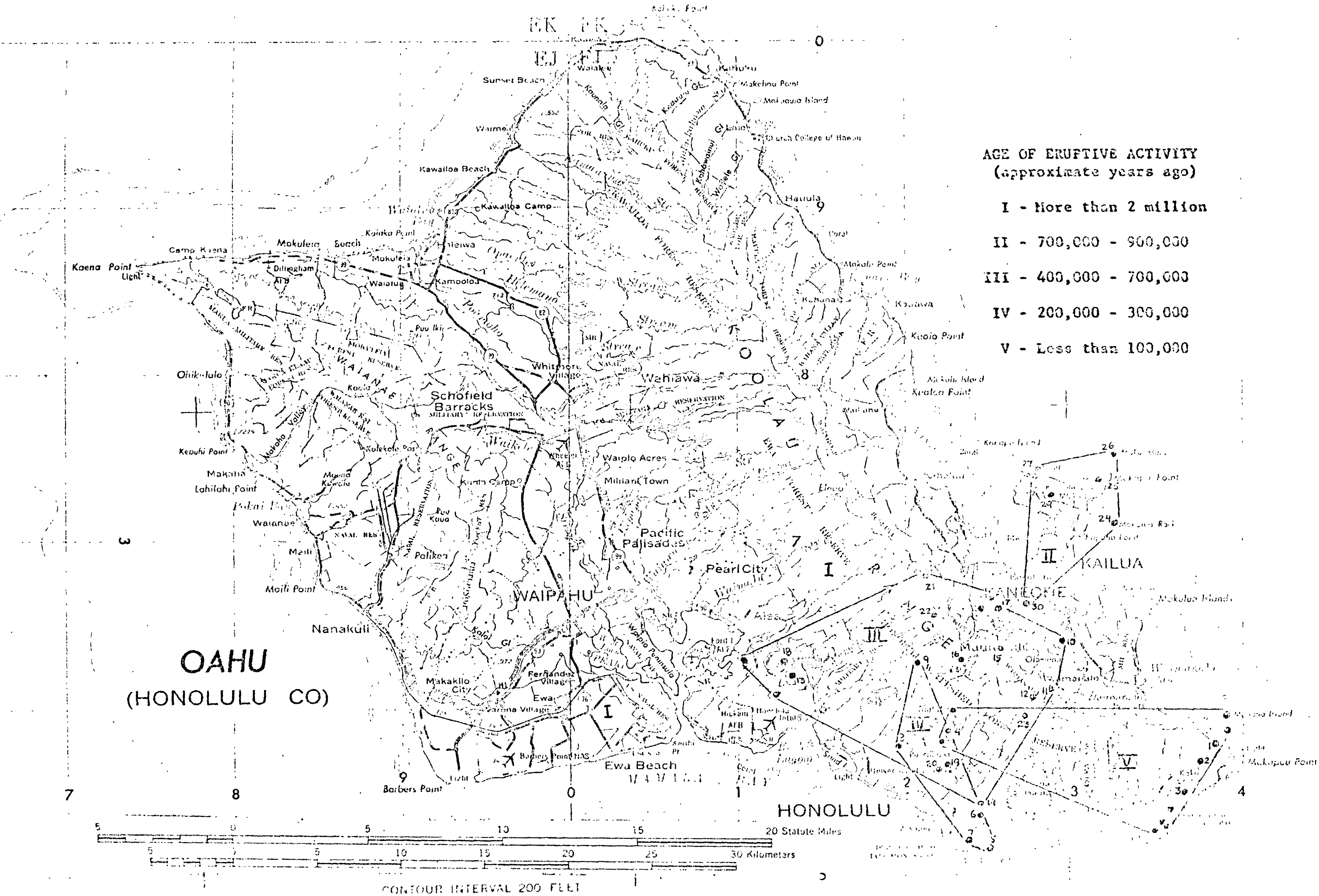

Fig. 1.--Location and ages of vents of the Honolulu Volcanic Series (data from Stearns, 1939, and Gramlich and others, 1971). Numbered vents are shown in Table 1.

of a line drawn from Pearl Harbor to the Mokapu Peninsula (fig. 1). Rocks erupted during the Honolulu period are known as the Honolulu Volcanic Series, and form such well-known landmarks as Punchbowl and Diamond Head.

The magma that formed the Honolulu rocks consisted of alkali basalt and nephelinitic basalt, which are poorer in silicon and richer in potassium and sodium than the alkali basalts of the shield volcanoes. Macdonald and Abbott (1970, p. 370) pointed out that volcanism which produced the Honolulu Volcanic Series probably was not simply a renewal of activity of the Koolau volcano, because the composition of the Honolulu rocks suggests that they originated at a much greater depth than did the Koolau magmas.

The same sequence of types of volcanism and kinds of rocks seems to characterize the life history of other Hawaiian volcanoes, although not all of them have gone through all the stages (Macdonald and Abbott, 1970, p. 138). The nephelinitic basalt phase thus occurs only after the other two phases, and after reaching this stage a volcano evidently never reverts to its earlier eruptive behavior. If volcanism recurs on Oahu, it almost certainly will be of the same general type and scale as that of the Honolulu period. For this reason, the nature of the eruptions of the last million years is subsequently described in some detail.

HONOLULU ERUPTIVE PERIOD

Eruptions during the last million years have occurred at more than 40 separate vents in the southeastern part of Oahu (fig. 1). Some of these vents are on high ridges in the Koolau Range, and others are on the southern coastal plain of the island, in areas that were near or below sea level when the eruptions occurred. The position of the vents seems to be partly random and partly controlled by northeastward-trending rifts or fracture zones which intersect the principal rift zone of the Koolau shield volcano at nearly a right angle. The genetic relation of the alined vents of the Honolulu Volcanic Series to the Koolau volcano is in doubt. Winchell (1947) suggested that Diamond Head lies at the south end of an "underdeveloped" rift zone of that volcano, and Bigelow (1969) inferred that the Honolulu Volcanic Series was erupted from dike fissures formed along a zone of crustal weakness in the Koolau volcano. However, Macdonald (1968, p. 516) proposed, instead, that the post-erosion eruptions of nephelinitic basalt on Hawaiian volcanoes, such as the Honolulu Series, occur along fissures which are of tectonic origin and related to fundamental crustal structures of the Pacific Basin. The term "rift zone" will be used in this report without implying that such a zone is necessarily related genetically to structures of a large shield volcano. Thus, rift zones on Oahu are unlike the rift zones of Kilauea and Mauna Loa on Hawaii, which are the principal loci of recent activity at those volcanoes.

Volcanism during the Honolulu eruptive period produced tephra (airborne volcanic-rock debris) and lava flows. In areas where the upward-moving magma did not encounter large amounts of water, tephra was erupted high into the air by the force of uprushing gases released from the magma as it neared the surface. Macdonald and Abbott (1970, p. 146) pointed out that the eruptions of the Honolulu period were rather explosive, and suggested that this was due to relatively abundant gas in the magmas of that period. Where the upward-moving magma encountered water-saturated rocks, eruptions of tephra were accompanied by repeated steam explosions which threw out great quantities of highly pulverized rock debris. Although most of the debris was basalt glass, it included various amounts of older volcanic rock and coral-reef rock through which the magma ascended. Eruptions like these were most common in coastal-plain areas where the water table was high. During a late stage of the eruptions, lava was extruded which generally formed a single, small, rather fluid flow. Only one small shield volcano was formed on Oahu during the Honolulu period. It was built by a succession of lava flows from a single eruptive center in the Kaimuki district directly north of Diamond Head (fig. 1) and covers an area of about 4 km^2. The longest lava flow of the Honolulu period extended a distance of at least 7 km down the Kalihi valley northwest of downtown Honolulu (Stearns, 1939, pl. 2).

Rocks of the Honolulu Volcanic Series have been dated with respect to shorelines and deposits formed during successive Pleistocene stands of higher and lower sea level, and by potassium-argon age determinations on whole-rock samples from some lava flows. The succession of eruptive events and their inferred relative and radiometric ages are shown in table 1.

Although the average frequency of eruptions during the last million years is about 1 per 25,000 years, the grouping of eruptions during certain periods indicates that the 40-odd eruptions of Honolulu time were not evenly spaced at 25,000-year intervals. Most radiometric age determinations on lava flows of the Honolulu Volcanic Series seem to fall into three groups: less than 100,000, 200,000-300,000, and 400,000-700,000 years. Intervals of 100,000-200,000 years which separate these groups may represent times when there was no significant volcanic activity on the island. It is possible, of course, that future radiometric dating of the other flows in the Honolulu Volcanic Series will shorten the apparent duration of the dormant intervals.

The relative age relations of volcanic rocks to various stands of sea level, as well as the radiometric dates, suggest a crude zonation of volcanism by age during Honolulu time (fig. 1). Eruptions during the earliest stage, possibly between 700,000 and 900,000 years ago, were limited to the windward side of the Koolau Range, and most occurred at the site of the Mokapu Peninsula. The next stage, between 400,000 and 700,000 years ago, was characterized by eruptions at widely scattered vents on both sides of the Koolau Range and nearly as far west as Pearl Harbor. The third stage, between 200,000 and 300,000 years ago, was limited to eruptions at a few vents in the Honolulu area, and included the formation of the Punchbowl and Diamond Head cones as well as the small shield volcano in the Kaimuki district. The fourth and final stage of activity included the Sugar Loaf-Tantalus eruptions on the southwest side of the Koolau Range and eruptions at 9 or 10 vents along the Koko rift at the southeast tip of Oahu. This pattern of activity suggests that there was a general trend toward progressively younger volcanism initially from north to south, and then from west to east.

Table 1.--Ages of some parts of the Honolulu Volcanic Series. Most data are from a similar compilation by Macdonald and Abbott (1970), which was based chiefly on the sequence presented by Winchell (1947); K-Ar dates are from Gramlich, Lewis, and Naughton (1971); correlations of sea-level stands with the mainland Pleistocene sequence are from Stearns (1974). Locations of eruptions are shown by number on figure 1

Eruption	Stand of sea level	Inferred correlation with mainland Pleistocene glacial-nonglacial sequence	Calculated K-Ar age (years)	Resulting deposits
Koko rift				
1. Kaupo			31,000±5,000 33,000±3,000	Spatter cone, lava flow.
2. Kalama			32,400±5,400 36,100±3,600	Cinder cone, lava flow.
3. Koko Crater			35,500±2,200 43,400±1,000	Tuff cone, lava flow.
4. Sugar Loaf			66,000±3,000 68,000±3,000	Cinder cone, ash, lava flow.
5. Black Point	-350? ft (Waipio).	Illinoian	272,000±10,000 283,000±19,000 287,000±8,000 288,000±9,000 316,000±10,000	Lava flow.
6. Kaimuki	---do---	----do----	286,000±12,000 289,000±7,000	Lava flows (shield volcano).
7. Diamond Head	---do---	----do----		Tuff cone.
8. Punchbowl	---do---	----do----	296,000±10,000 297,000±6,000	Tuff cone, lava flows.
9. Kamanaiki	---do---	----do----		Lava flows.
10. Training school	---do---	----do----		Cinder cone, lava flow, mudflow.
11. Maunawili	---do---	----do----		Cinder cone, lava flow.
12. Ainoni	---do---	----do----		Do.

13.	Salt Lake	---do----	----do----	418,000±18,000 430,000±25,000 446,000±21,000	Tuff cone, lava flow.
14.	Mauumae	+70 ft (Laie)	Late Yarmouth or early Illinoian.		Spatter cone, lava flow.
15.	Pali[1]	+95 ft (Kaena)	Yarmouth	ca. 425,000±20,000?	Cinder cone, lava flow.
16.	Nuuanu (Luakaha and Makuku).	---do----	----do----	416,000±10,000 422,000±13,000	Cinder cones, lava flows.
17.	Kaneohe	---do----	----do----		Cinder cones, lava flow.
18.	Aliamanu	---do----	----do----		Tuff cone, lava flow.
19.	Manoa	---do----	----do----		Cinder cone, lava flow?
20.	Rocky Hill	---do----	----do----		Spatter cones, lava flow.
21.	Haiku	---do----	----do----		Cinder cone, lava flow.
22.	Kalihi	---do----	----do----	457,000±11,000 464,000±22,000	Do.
23.	Kaau	---do----	----do----	617,000±9,000 677,000±23,000	Lava flows, tuff, mudflows.
24.	Mokolea	-350? ft (Kahipa)	Kansan		Lava flow.
25.	Ulupau	---do----	----do----		Tuff cone, lava flow?
26.	Moku Manu	---do----	----do----		Tuff cone.
27.	Pyramid Rock	---do----	----do----		Lava flow.
28.	Pali Kilo	---do----	----do----		Cinder cone?, lava flow.
29.	Hawaiiloa	---do----	----do----		Cinder cone, lava flow.
30.	Castle[2]	?	?	846,000±8,000 860,000±10,000	Do.

[1]Age based on inferred stratigraphic relation to the older Nuuanu lava flow and the younger Salt Lake lava flow.

[2]Castle lava flow assigned by Winchell (1947) to Waipio sea-level stand, but placed here in table on basis of K-Ar age determination. Macdonald (written commun., 1975) suggests that this determination is in error and is too old.

The relative ages of the Tantalus-Sugar Loaf eruptions and those along the Koko rift zone are in some doubt. The radiometric age of the Sugar Loaf flow (no. 4, table 1; fig. 1) probably represents the general age of a group of vents which includes the Sugar Loaf, Round Top, and Tantalus cinder cones. The eruptive products of this group have been regarded as some of the youngest volcanic formations on Oahu, and somewhat younger than tephra and lava flows along the Koko rift (Winchell, 1947, p. 45-46). However, the potassium-argon age of the flow from Sugar Loaf is about twice as great as that of two lava flows from the Koko rift zone (Gramlich and others, 1971). The Koko and Tantalus-Sugar Loaf groups of volcanic rocks evidently do not represent simultaneous eruptions from the same magma chamber, because rocks of the two groups represent the extremes of chemical composition found in the Honolulu Volcanic Series (Winchell, 1947, p. 44).

Descriptions of soils on the Tantalus-Sugar Loaf deposits and on the volcanic deposits of the Koko rift zone (Foote and others, 1972) seem to suggest that the Tantalus-Sugar Loaf deposits are not twice as old as the others and may, instead, be of the same general age or even younger. This apparent contradiction might be resolved by additional radiometric age determinations.

POTENTIAL VOLCANIC HAZARDS

The eruptive record of the last million years on Oahu suggests that if volcanism does recur, it will be limited to the southeastern part of the island. The part of Oahu that lies on the leeward side of the Koolau Range and from Tantalus southward and southeastward is thought to have the highest relative degree of risk. However, the overall degree of risk in that zone probably is less than that on any part of Mauna Kea volcano on the island of Hawaii (Mullineaux and Peterson, 1974, p. 52) and may not be significantly different from that on Kohala volcano, which is in the zone of least relative risk on that island. A more precise comparison cannot be made because none of the lavas erupted so far on Hawaii show a chemical affinity to the lavas of the Honolulu Volcanic Series.

The principal potential volcanic hazards on Oahu are subdivided according to kinds of volcanic events and their products; namely, tephra, lateral blasts, lava flows, and mudflows. The nature of each of these phenomena is discussed below.

Tephra

The term tephra is restricted here to volcanic rock debris which is erupted into the air above a volcano, and falls back to the ground surface after moving along a ballistic trajectory, or after being carried laterally by wind. The rock debris may be either vesicular, like cinders, or nonvesicular. Within a few kilometres of the source, tephra deposits may be interbedded with fragmental rock debris of similar lithology and texture which was transported by lateral blasts (p. 11). Tephra which becomes consolidated into firm rock is referred to as tuff.

The distribution of tephra deposits is determined by the height to which the material is erupted, its grain size and volume, and the direction and strength of winds blowing during the eruption. Hawaii is in the belt of prevailing northeasterly winds, and winds blow from that direction more persistently and with greater strength during the summer than during the winter (Armstrong, 1973). Between October and April, the passage of cold fronts may be preceded by strong southwesterly winds and followed by northerly winds. At Honolulu from 1905 to 1946, winds blew from the northeast and east sectors on an average of about 80 percent of the time (Wentworth, 1949, p. 86). Cyclical swings in the proportions of winds from these two sectors have occurred over a period of several decades.

Tephra deposits formed during Honolulu time are commonly tens to a few hundreds of metres thick within a kilometre or two of the vent, thin rapidly outward, and extend farthest in a downwind direction. On the basis of his observations of tephra deposits in the Honolulu Volcanic Series, Wentworth (1926) noted that thicknesses of as much as 1,000 feet (333 m) are common 1/2 mile (0.8 km) from the vent, 100-200 feet (33-66 m) at a distance of 1 mile (1.6 km), and are generally less than 10 feet (3 m) at a distance of 2 miles.

If an eruption occurs in the future, the likelihood that tephra will fall on certain parts of Oahu is shown schematically in figure 2. Increasing degrees of likelihood that a significant amount of tephra, say at least 10 cm, will fall in areas beyond the zone of most recent volcanism are shown on an arbitrary scale of 1 to 10, and are based chiefly on distance and direction. The assumption is made that there is at least a 65-percent chance that the wind will be blowing from the sector between NNE. and E. during the eruption. The thickest tephra probably would fall within a downwind distance of 1-2 km from the vent, and could amount to tens of metres; as much as 50 cm of tephra might fall within a downwind distance of about 5 km.

The scale of 1 to 10 is used to emphasize the gradational degree of likelihood that such an event would affect various areas. The likelihood that a significant amount of ash will fall decreases outward in all directions from the zone of most recent volcanism, but decreases more abruptly in directions away from those of the prevailing winds.

This suggestion of the relative degrees of risk from future tephra eruptions is based on the assumption that the vent will be at some point along a line that runs from Tantalus southwestward to the coast. A northeast wind blowing during an eruption would carry tephra across downtown Honolulu, and the distribution of the thickest deposits probably would resemble that of the Tantalus ash (Stearns, 1939, pl. 2). An east wind would carry tephra toward Pearl Harbor, and the north-south distribution of the resulting deposits would depend on the location of the vent and the variability of the wind. Figure 2 includes only the likelihood of fallout of tephra erupted from a vent in areas where there has been volcanism during the last 100,000 years. Tephra eruptions at vents in areas where volcanism occurred between 1 million and 100,000 years ago would result in a similar fallout pattern, but one which would extend farther northward and westward.

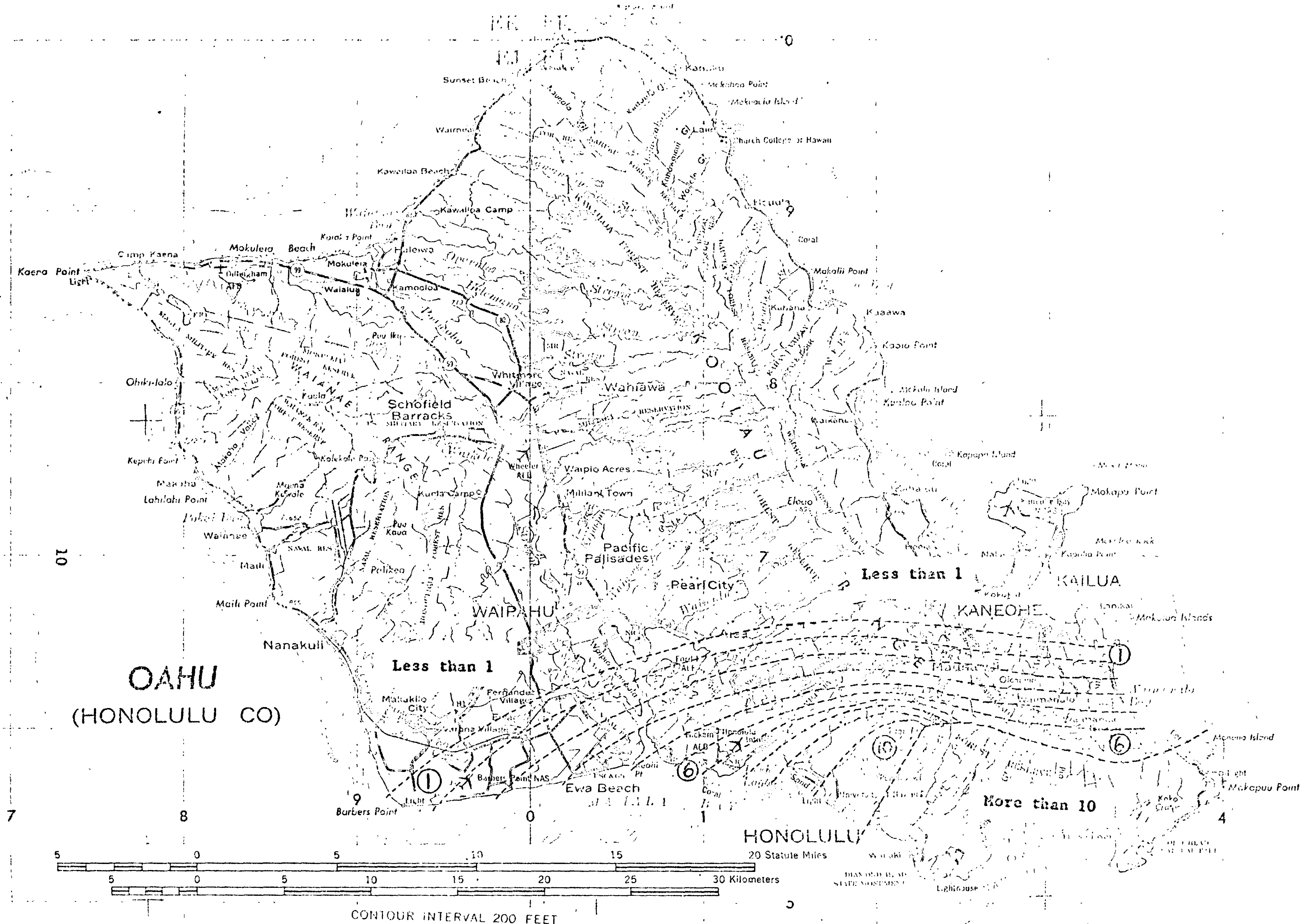

Fig. 2.--Diagrammatic representation (best guess) of relative risk on Oahu from fallout of tephra originating in the zone of most recent volcanism. Relative risk is greatest (more than 10) throughout that zone.

The eruption of tephra can have many hazardous effects, the severity of which is determined mostly by the temperature of the falling material, the thickness of the resulting deposits, and the rate at which they accumulate. Areas and structures within a kilometre or two of the vent can be devastated by falling bombs and cinders which are still very hot; this hazard decreases rapidly outward for material transported by wind. Falling rock fragments can cause impact damage within a distance of 2 or 3 km of the vent. Beyond that distance, principal hazards associated with the fall of tephra include (1) excessive loads on roofs, especially if the eruption is accompanied by rainfall; (2) abrasive effect of fine ash on machinery and especially on air-breathing engines; (3) pollution of exposed water supplies; (4) air pollution by particulate matter and gases; (5) reduced visibility, which could impede air and ground traffic and also result in a greater use of electric power for lighting during times of normally low use; (6) clogging of drains; (7) the damage or destruction of vegetation; and (8) chemical attack of metals by the acid gases carried by tephra. Gases erupted along with the tephra could constitute a serious threat to health within a distance of a few km of the vent, but dilution and dispersal by wind would quickly reduce the effects at greater distances.

Lateral blasts

Lateral blasts are clouds of gas, water, or rock particles, or mixtures of these which move along the surface of the ground at high speed. They may be hot or cold, and dry or moist. Velocities may be on the order of 20-50 metres per second. Lateral blasts can be caused by steam explosions when rising magma encounters sea water or water-saturated rocks. The cones of Diamond Head, Punchbowl, and Koko Crater, as well as others on Oahu's southeastern coastal plain, probably were formed by material erupted vertically above the vent and falling back to the ground surface, as well as by lateral blasts which carried the rock debris outward.

Although steam explosions are most likely at a vent located at or below sea level, they can occur anywhere that a magma encounters water. A series of vertically directed steam explosions at Kilauea on Hawaii in 1924 probably were caused by ground water draining from rocks surrounding the caldera into the conduit of the volcano (Macdonald, 1972, p. 245).

A lateral blast is dangerous because of its high speed, the rock debris that it can carry, and, in some cases, because of heat. Such blasts can affect areas on one or all sides of a vent, depending on the direction of the initial explosion, topographic features adjacent to the vent, and the manner of origin of the blast.

Lateral blasts which originated in 1964 at Taal volcano in the Philippines totally removed all trees within a distance of 1 km of the explosion crater and sandblasted trees out to a distance of 6 km (Moore, 1967).

Areas of differing degrees of potential risk from lateral blasts are subdivided according to the age of the most recent volcanism in that area (fig. 3). A maximum distance at which a lateral blast will have a hazardous effect is assumed to be 8 km from the vent, and the boundaries of

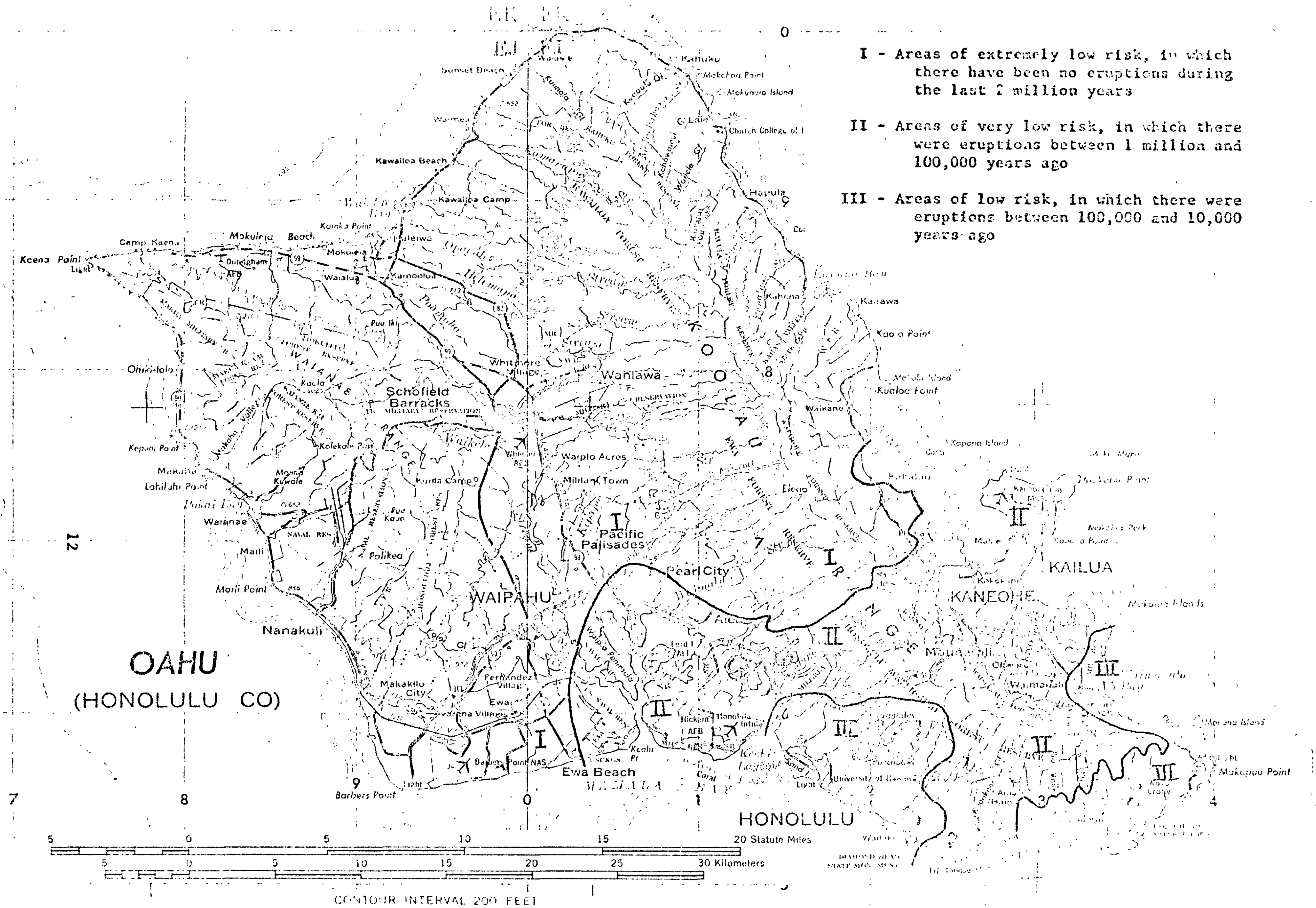

Fig. 3.--Zones of relative risk from lateral blasts.

zones are placed according to distance and topography. The effects that manmade structures might have on lateral blasts were not considered in drawing the boundaries of the zones.

Lava flows

Lava flows erupted on Oahu during the last million years have been mostly of small volume and typically seem to have occurred singly. If future lava flows are similar to those of the Honolulu Volcanic Series, they may be erupted from vents located in nearly any topographic environment, from ridgetop to flat coastal plain. Although their precise point of origin can not be anticipated, they predictably will move downslope from their vent until an obstacle is reached, or until the supply of lava stops. Lava flows tend to move down depressions such as stream valleys, but will spread across broad flat areas of low slope. A flow may extend offshore if enough lava is erupted.

Areas of differing degrees of potential hazard from future lava flows are shown in figure 4, and the relative risk is based chiefly on the age of the last eruptive activity in specified areas. Lava flows generally have little direct effect on areas beyond their margins; thus, the boundaries of the zones are drawn along the sides of valleys which are thought to be susceptible to burial by lava flows. The effects of buildings, highways, and other manmade structures on the path of lava flows were not considered in drawing the boundaries of the risk zones. The area of lowest relative risk (zone I) has not been affected by lava flows during the last 2 million years. Zone II includes areas in which there has been volcanic activity within the last million years, and zone III, which has been affected by volcanism during the last 100,000 years, has a higher relative degree of risk from lava flows than any other area on the island.

Lava flows can nearly or totally destroy structures in areas they cover, and thus are probably the most hazardous and destructive kind of volcanic event with respect to property. However, they seldom directly threaten human lives because people can move away from threatened areas faster than the flow can advance. Moreover, during eruptions that produced the Honolulu Volcanic Series, lava flows seem to have followed other kinds of eruptive activity. In such circumstances, threatened areas would be evacuated because of other kinds of risks long before lava flows were erupted. The rate of advance of a lava flow on relatively flat ground could range from less than 1 m to perhaps as much as 1 km per hour. More rapid rates generally occur only where lava is flowing down a steep slope. Strong structures such as buildings and concrete walls tend to deflect lava flows, and the path of flows can be influenced to some extent by artificial embankments (Macdonald, 1958) and by spraying large volumes of water on their fronts (Sylvester and others, 1973).

Mudflows

Mudflows are mixtures of fine to coarse rock debris and water which travel down slopes and down valleys like masses of wet concrete. They commonly originate at active volcanoes where rainfall saturates loose, recently deposited tephra on steep slopes. The deposits of mudflows formed in this

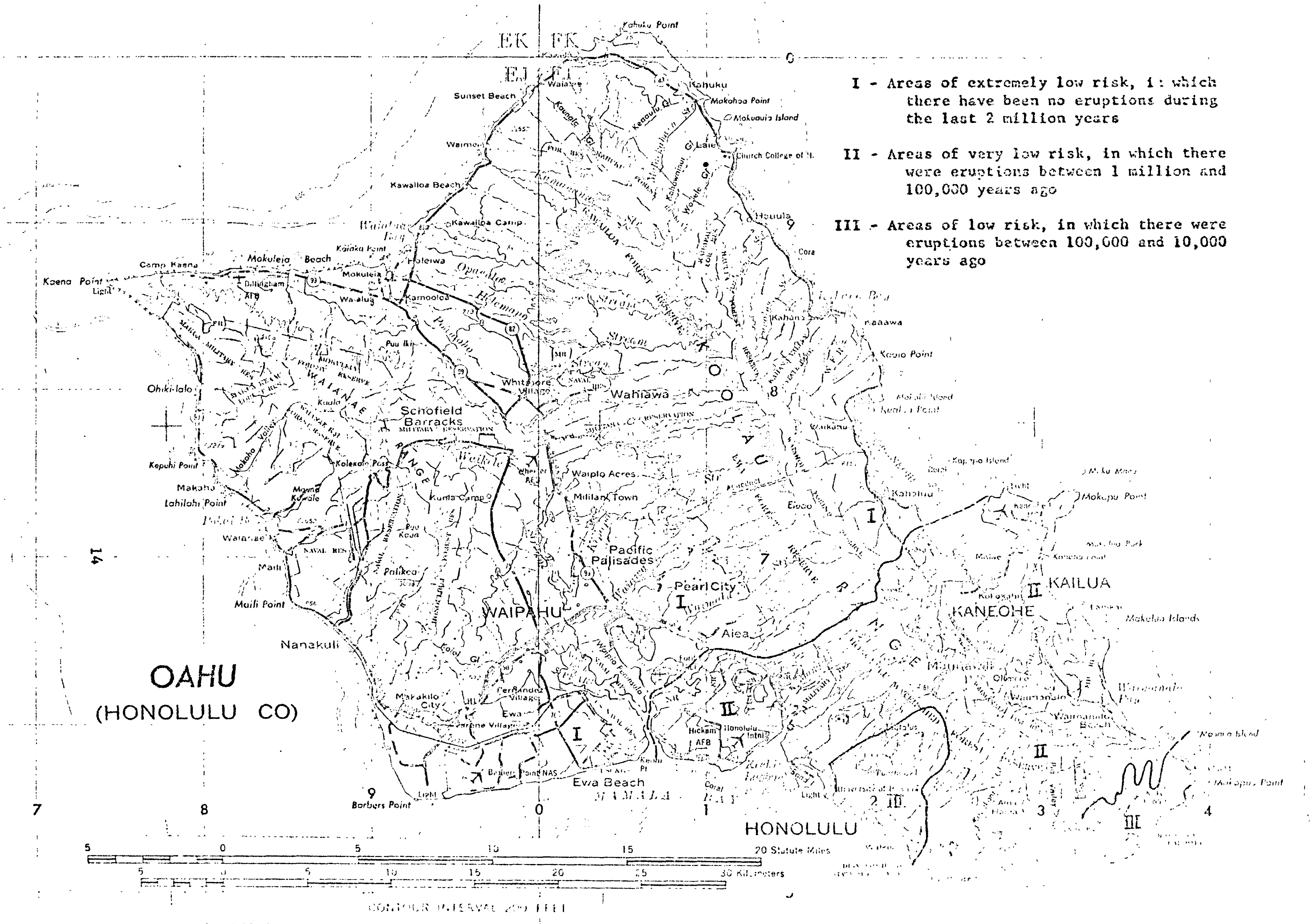

Fig. 4.--Zones of relative risk from lava flows.

way during the Honolulu period have been recognized at several places in valleys on the leeward side of the Koolau Range (Stearns and Vaksvik, 1935, p. 105-124), and on the windward side such a deposit underlies a lava flow from the Training School vent (G. A. Macdonald, written commun., 1975). The mudflow deposits are interbedded with stream-deposited gravels, tephra deposits, and lava flows, and one deposit thought to be of mudflow origin is as much as 18 m thick (Stearns and Vaksvik, 1935, p. 124). The mudflow deposits consist of scattered large rock fragments in a matrix of reworked tephra, and some contain abundant vegetative matter.

Future mudflows probably would follow an eruption which produced thick tephra deposits. Tephra on narrow ridgetops and steep hillsides would be especially susceptible to downslope movement if saturated with rain, and masses of water-soaked tephra could flow from hillsides onto valley floors. If enough wet material were set in motion simultaneously, the resulting mudflow could move many kilometres down a valley floor and bury it under tens of metres of mud and rock debris. Mudflows originating on the leeward slope of the Koolau Range could spread onto certain parts of the coastal plain of southeastern Oahu.

Zones of differing degrees of risk from future mudflows are differentiated according to the times of the most recent volcanism in various areas (fig. 5), and zone boundaries are based on the assumption that the formation of mudflows requires the deposition on steep slopes of a significant amount, perhaps half a metre, of tephra.

Mudflows can be dangerous because of their possible length, depth, and speed. Some mudflows have been reported to move at speeds of more than 30 km/hr, but on gentle slopes they move more slowly. Because of their high density, they have great transporting power and can carry large goulders as well as manmade objects. They behave in many ways like floods of water, but water tends to drain away after the flood crest has passed, whereas mudflows come to rest and form thick, permanent deposits.

PERSPECTIVE

Radiometric dating of lava flows in the Honolulu Volcanic Series has provided new information concerning the recency of volcanism on Oahu, as well as the duration of dormant periods between eruptions. Even so, the sporadic nature of volcanism during the last million years, and the long duration of dormant periods, make the prediction of future volcanic activity impossible, even in terms of tens of thousands of years. Not only has there evidently been a lack of activity during the seven or more centuries since man first settled the Hawaiian Islands, but there probably has been no volcanism within at least the last 10,000 years. Under such circumstances, it is inappropriate to suggest that the residents of Oahu should be concerned with potential hazards from future volcanism in planning land use for the next few decades. Instead, the most practical approach seems to be to take a calculated gamble, but one with very great odds in our favor, that there will be no significant economic loss from volcanic activity on Oahu in the foreseeable future. In the event that an eruption should occur, prompt evacuation of threatened areas surely would prevent loss of life.

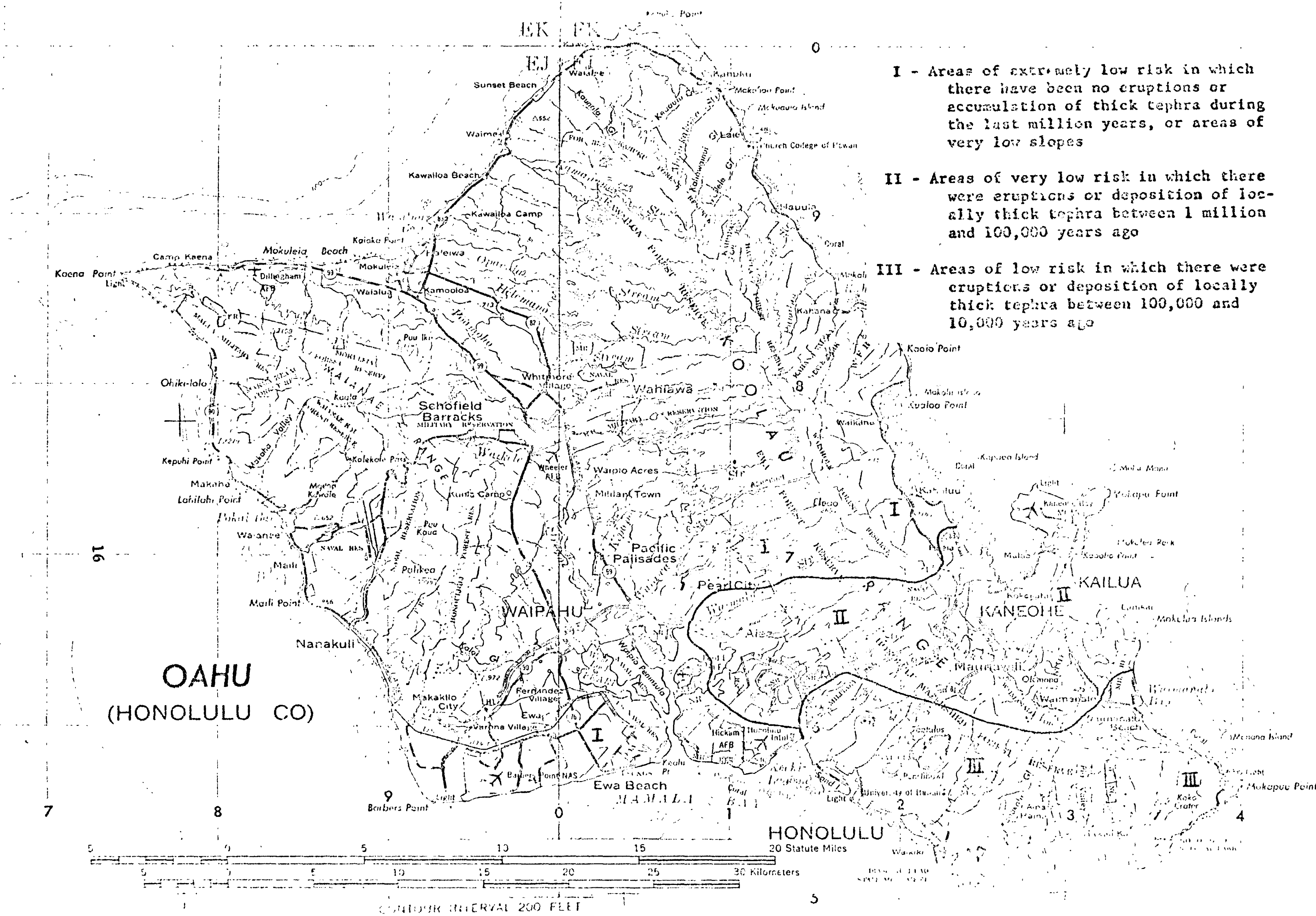

Fig. 5.--Zones of relative risk from mudflows.

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